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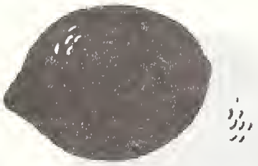

Protective Services
FOR SHIPMENTS OF CARTON LOADS OF
California ORANGES and LEMONS

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Market Quality Research Division

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Members of the test parties were:

Test 1.--Carl Waldapfel, Field Laboratory, Sunkist Growers, Inc.; Art Anderson, Pacific Fruit Express; and John Worthington and E. P. Atrops, U. S. Department of Agriculture.

Test 2.--Glenn Goodwin, Field Laboratory, Sunkist Growers, Inc.; James Orr, Pacific Fruit Express; and W. H. Redit and E. P. Atrops, U. S. Department of Agriculture.

Washington, D. C. February 1962

SUMMARY AND RECOMMENDATIONS

Modified icing services, together with some form of precooling, resulted in satisfactory transit protection for California citrus shipped in hot weather. Winter shipments cooled almost as well under ventilation as with ice refrigeration except for a 24- to 30-hour delay in reaching cold weather on the northern route. Thermostatically controlled continuously powered fans in iced cars provided the best cooling and transit temperatures.

Transit temperatures of oranges and lemons, as affected by various protective services, were obtained in two transcontinental tests from California to New York City. One test of 14 cars of Valencia oranges and lemons was conducted from southern California districts in August. In the other, 12 cars of navel oranges were shipped from the central California area in January. In the latter test, two thermostatically controlled fan cars were included. All other cars were of the conventional electric fan type.

Summer oranges in test No. 1 had the lowest average fruit temperatures in transit (40° F.) in the three loads of shipper-precooled oranges (room precooled). All three cars were pre-iced and replenished. One was full bunker re-iced once, another full bunker re-iced twice, and the third half-stage Standard Refrigeration. All were equally effective in providing satisfactory transit temperatures.

Full bunker, pre-iced cars loaded with warm oranges and precooled for 8 hours by the carrier, replenished, and re-iced once in transit had average temperatures of 44° and 48°F. for the trip. Average fruit temperature reached 45° in 96 hours in one car and 154 hours in the other. Fruit temperatures in nonprecooled cars were much higher, averaging 55°, 55°, and 51° for the trip. These cars were pre-iced and replenished, the first moving under half-stage Standard Refrigeration, the other two full bunker, with two re-icings in transit. The rate of cooling was slow in two of these cars with flues open and required 128 to 134 hours after loading for the average fruit temperature to reach 45°. In the other car with the wall flues closed, the fruit cooled more quickly and reached 45° in 84 hours.

This test indicates that summer oranges require some precooling to reduce temperatures to a safe level of 45° F. quickly, whether shipped with half-stage Standard Refrigeration or with full bunker and one or two re-icings in transit. Cars should be pre-iced and replenished if the fruit is loaded warm and not precooled.

Summer lemons in vented cartons cooled faster and to a lower temperature than those in unvented cartons, whether shipped under half-stage Standard Refrigeration or with two re-icings in transit. In cars with vented cartons, the average fruit temperature reached 55° F. transit temperature in 24 to 36 hours after loading and continued to cool to near 40° at destination. In cars with nonvented cartons, it took from 42 to 72 hours to reach 55° and destination temperatures ranged from 45° to 52° . The results indicate that lemons packed in either nonvented or vented cartons could probably move safely with only one re-icing in transit.

Winter oranges in test No. 2, moving under ventilation from origin to Ogden, Utah, cooled slowly during the first 40 hours after loading because of slow movement and warm weather as far as Donner Pass. Cooling was satisfactory beyond this point where cold weather was encountered. After the vents were closed, temperatures averaged around 45° F. for the remainder of the trip.

The cooling of fruit in cars pre-iced, replenished, and not re-iced in transit was slow for the first 30 to 40 hours in transit, due to the usual slow car speed during the period. The oranges cooled to around 50°F. at this point, compared to around 55° for the ventilated cars. Cooling continued in the iced cars for the rest of the trip, averaging 35° to 38° at destination.

Fruit was cooled to the thermostat setting of 42° F. in about 30 hours in a car equipped with thermostatically controlled, continuously powered fans. Transit temperatures remained close to this point for the remainder of the trip. Overall performance was considerably better than that of the conventional fan cars with power generated by the car wheels, and lacking thermostatic controls.

Oranges loaded in the spaced bonded-block pattern cooled more rapidly and more uniformly than those loaded in the usual bonded chimney pattern.

A slight advantage was noted in cooling rate and uniformity of fruit temperatures when the wall flues were closed in iced cars. Closing the wall flues produced little effect in the ventilated cars.

PROTECTIVE SERVICES FOR SHIPMENTS OF CARTON LOADS OF CALIFORNIA ORANGES AND LEMONS

3a

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INTRODUCTION

The last previous accompanied citrus transportation test from southern California was made in July 1952 (3)[1] and the last similar test from central California over the northern route was loaded in January 1951 (2). Further studies on protection of citrus fruit in transit from these areas were made through unaccompanied shipping tests (1, 4, 5). Those reports cover a period of transition from the wooden crate, which had been the standard container for many years, to the new fiberboard carton. At that time, many types of cartons were in existence.

As a standard carton has now been adopted by the industry, it was considered desirable to re-evaluate the protective services available in the light of the new container. In addition, faster train schedules permit seventh-morning delivery to New York City, compared with 8 to 10 days previously. This reduced transit time enables the railroads to omit one or two regular icing stops on a cross-country trip. Therefore, it was necessary to determine the effects of these changed icing practices on cars moving under faster schedules.

This report gives the results of two accompanied cross-country shipments from California to New York. The 14 cars of test 1 were loaded on August 26 and 27, 1959. Eight of these contained Valencia oranges from the Santa Paula, Fillmore, and Orange districts; the remaining six cars contained lemons from the Oxnard area. The 12 cars of navel oranges in test 2 were loaded on January 20, 1960, in the central California area (Sanger to Terra Bella).

MATERIALS AND TEST PROCEDURE

Test Cars

The 26 cars chosen for the 2 tests were from 1 series of refrigerator cars equipped with electric fans and wall flues. Full-bunker ice capacity rating was 11,500 pounds of chunk ice, and half-stage capacity was 6,000 pounds.

Fans on all cars were operated in the "on" position and, except for cars 2-A and 2-B (test No. 2), the fans were in operation only when the train was in motion and at speeds proportional to the train speed. Cars 2-A and 2-B were experimental thermostatically controlled fan cars which are described under test No. 2.

Containers

The telescope carton, which provides double sides and ends, has now been in use for over 4 years. The standard container's inside dimensions are 10 1/16 inches wide, 16 3/8 inches long, and 10 1/4 inches high. It has been used with or without vents for lemons and precooled oranges, but the trend has been toward more venting, especially for warm oranges. There are two common methods of ventilating this carton: (1) By two slots, about 3/4 x 4 inches, cut in the top and bottom on the centerline; and (2) by eighteen 1-inch holes, six punched into the top and six into the bottom, and three into each side on a line midway between the top and bottom. The latter 18-hole carton was used in 6 of the 8 Valencia orange cars and 3 of the 6 lemon cars of test 1. Slot-type vents were used in the two remaining orange cars, and nonvented cartons were used in the three remaining lemon cars. All of the cars included in test 2 had the 18-hole cartons. The loading pattern used is described in the sections for tests Nos. 1 and 2.

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[1] Underscored numbers in parentheses refer to items in Literature Cited, p. 28.

Biphenyl-treated sheets, approximately 10 x 16 inches (usually two per carton), were used to protect the fruit from Penicillium decay and soilage. These sheets are perforated to match the vent holes in the carton. For oranges, they are commonly placed between layers of fruit during place packing to give the highest concentration of biphenyl vapor near the center of the carton. For lemons, the sheets are generally placed in the top and bottom of the carton so they will not interfere with volume fill or bulk packing operations.

Placement of Temperature-Measuring Equipment

Temperatures of the fruit within each test car were obtained with 3 thermographs and a thermocouple cable having 11 thermocouple positions with a selector switch mounted on the running board on top of the car. From this location, the individual thermocouples inside the car were read with a potentiometer. In both tests, nine of the thermocouples were inserted directly into fruit located near the centers of the cartons. Three vertical centerline positions were used: Top, middle, and bottom layers. These three positions were used at the bunker, quarterlength, and doorway locations. One thermocouple in each car was located near the ceiling opposite the middle fan for taking TA (top air) temperatures. Another thermocouple under the floor rack at the bunker gave BA (bottom air) temperatures.

One thermograph was placed in the center of a carton of fruit at the quarterlength in the third layer, adjacent to the carton containing the MQ (middle quarterlength) thermocouple. One thermograph was fastened to the ceiling and another under the floor rack, both at the quarterlength. These three thermographs gave continuous records for MQ cartons and top and bottom air temperatures, whereas the thermocouple temperatures could be obtained only at stations where stops allowed sufficient time to make readings.

Additions of ice, weather conditions en route, and fruit condition at unloading were recorded by the test party.

TEST RESULTS

Test No. 1, Summer, Valencia Oranges and Lemons

Cars were loaded August 26 and 27, 1959, and arrived at Jersey City September 2.

Route and Running Time

This test of 14 cars, 8 with Valencia oranges and 6 with lemons, was routed from southern California, via Southern Pacific, Rock Island, Indiana Harbor Belt, and Erie, to Jersey City and the New York market area. The total elapsed time from Colton, Calif., to Jersey City, N. J., was 128.5 hours; 87 hours (68 per cent) of this was running time, and 41.5 (32 per cent) was standing time (table 1). This trip was 44 hours shorter in total elapsed time than the average of four previous accompanied trips made 7 to 10 years ago, because 13 hours had been cut from the previous average running time and 31 hours from the standing time. The average running speed for the 3,300-mile trip was increased from 33.2 miles per hour to 38.0 miles.

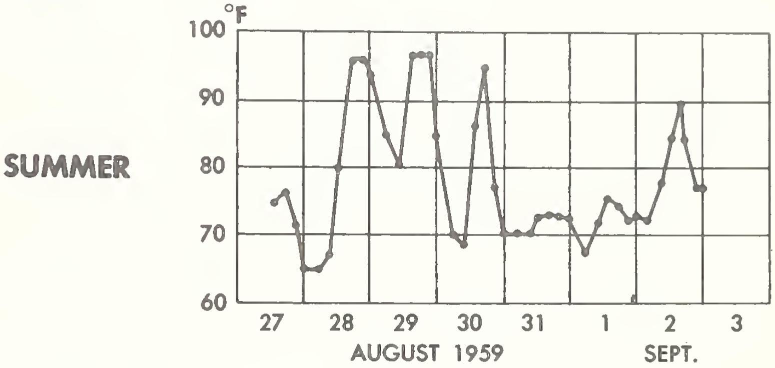
Weather Conditions

The average outside temperature for the trip was 80° F. (fig. 1). Maximum temperatures for the first 3 days en route were 97°, 97°, and 96°, respectively; daily averages for the same 3 days were 82°, 90°, and 78°. Rain showers were encountered between Tucumcari, N. Mex., and Hornell, N. Y., on August 30 through September 1. Average temperature for this part of the trip was 72°. The average temperature for the 5 days while the orange cars were standing at Jersey City was 77°.

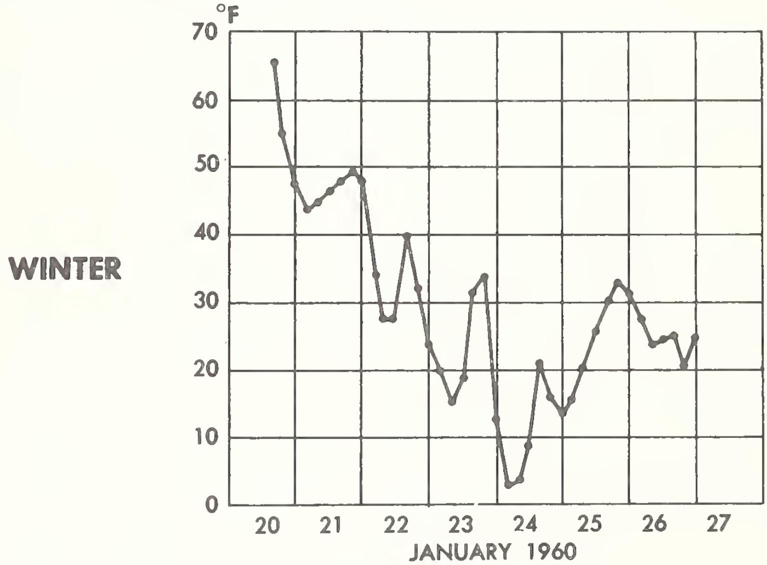
Figure 1

OUTSIDE AIR TEMPERATURES

Test 1 - Southern California to New York



Test 2 - Central California to New York



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Loads

The bonded chimney pattern load was used in all the test cars. Each of the orange cars contained a total of 1,012 cartons, including 82 cartons as a deck load, forming a partial sixth layer. Cars 1-C and 1-D, loaded with oranges, were the only test cars with slot-type carton ventilation; all other vented cartons were of the 18-hole type. The cars were loaded from each of seven packing houses. The lemon loads contained 930 cartons and were 5 layers high. Of the six lemon cars, one car from each of three houses was loaded with ventilated cartons and one with nonvented cartons.

Protective Services

All cars were iced before loading. Cars 1-C and 1-D were supplied with full bunkers of ice by the shipper just before loading; therefore, they were not replenished as were the other 12 (tables 2, 3, 4).

Cars 1-A and 1-B were loaded on August 26, 1 day before the others, and received 8 hours of carrier precooling on August 27.

Re-icing services included one and two re-icings en route, and half-stage Standard Refrigeration.

The wall flues in car 1-H (oranges) were closed at the top opening. This car, and the companion car 1-G with flues open, were pre-iced full bunker; both were loaded from the same house and received two re-icings en route.

Cars 1-C, 1-D, and 1-F were loaded with house-precooled oranges. All other orange cars had warm loads.

Results with Valencia Oranges

The lowest average fruit temperature for the trip was maintained by the three shipper-precooled cars (table 5). Car 1-C, with an average temperature of 41.9° F., received re-icings at El Paso, Tex. (1,900 pounds), and Marion, Ohio (5,100 pounds), and did not require additional ice at destination. Car 1-D, with an average temperature of 39.9°, received a re-icing of 6,000 pounds at Kansas City and an additional 7,000 pounds at destination. Since over 3,000 pounds of ice remained on arrival at Jersey City, a re-icing of less than the 7,000 pounds added should have been adequate for this car. These cars used a total of about 13,000 and 14,000 pounds of ice, respectively, the lowest ice consumption of any cars in the test.

Car 1-F had an average fruit temperature of 41.9° for the trip. It was billed half-stage Standard Refrigeration, and estimates show it used about 18,000 pounds of ice to take care of heat leakage and to reduce the average fruit temperature only 1.7 degree. The reason for the use of an extra 4,000 or 5,000 pounds of ice by this car is not immediately explainable but it is suspected that individual car characteristics may be an important factor. The approximate amounts of ice used by other cars are given in table 3 (oranges) and table 4 (lemons).

The next lowest average fruit temperatures were in cars 1-A and 1-B, 44.4° and 47.9° F., respectively (table 5). These were carrier-precooled for 8 hours. Loads and icing services were the same for both cars, pre-iced, replenished, and re-iced once in transit at Kansas City. Sixteen hours after precooling and 30 hours after loading, when the cars were at Colton, Calif., the average temperatures were 49.0° in car 1-A and 54.1° in 1-B. At this time, the minimum temperature in 1-A was 10 degrees lower than that of the companion car. This difference was partially maintained throughout the trip and was reflected in the lower average temperature.

An explanation of table 5 will clarify differences between cars 1-A and 1-B as well as between other cars of this test. The extreme right hand column headed "Difference MQ-TA" under thermograph temperatures shows 2 degrees for 1-A and 9 degrees for 1-B, the car which required about 50 hours longer than car 1-A to reach an average fruit temperature of 45° F. Since the top air, which averaged 44° in both cars, is forced down through the load by the fans, we should expect similar results at the MQ thermograph position provided the same amount of air was moved over that position by the fans. Apparently, the same amount of air did not pass over the MQ position in the two cars. Data are not available to pinpoint the reasons.

Cars 1-E and 1-G, loaded with warm fruit, had average fruit temperatures for the trip of 54.9° and 54.6° F., respectively. Average fruit temperatures did not reach 45° in these cars (with flues open) until about 130 hours after loading, or near Jersey City. The average difference between TA (thermograph) and MQ carton (thermograph) temperatures was 10 degrees from Tucson to Jersey City in both cars. The average difference in maximum and minimum temperatures was also 10 degrees for the same portion of the trip. The temperature curves for these cars show almost identical rates of cooling (fig. 2).

Car 1-H, which had an average fruit temperature of 51.4° F. for the trip, was the only car in the test with flues closed. It was loaded under the same conditions as cars 1-E and 1-G. An average fruit temperature of 45° F. was reached about 84 hours after loading, or about 46 hours sooner than cars 1-E and 1-G. The average difference between TA thermograph and MQ carton temperature was only 5 degrees in car 1-H as compared to 10 degrees in cars 1-E and 1-G, indicating a better rate of heat transfer from the middle layer cartons of car 1-H. The average temperature of car 1-H, with closed flues, was 3 degrees lower than those of cars 1-E and 1-G, which had flues open (table 5 and fig. 2).

The orange cars remained on track in Jersey City from early on September 3 to the evening of September 7. Inspection of the fruit on the auction floor the following morning revealed no apparent difference among any of the test lots of warm-loaded oranges. There was an occasional decayed fruit, but this was not considered of any commercial importance. The oranges from precooled loads had a slightly fresher appearance and no decay was noted.

Discussion: Valencia Oranges

In this test, there was little difference between full-bunker icing with two re-icings en route (1-G) and half-stage Standard Refrigeration (1-E). The latter service, however, offers the advantage of more frequent re-icing at little or no additional cost. This is an advantage to the shipper who has diversions to consider when choosing an icing service.

The data available indicate that, for warm-weather shipments of non-precooled oranges, the flues allow much of the cold air to pass over the warm side walls of the car structure. When the flues are closed or are not present, this cold air is forced through the load, resulting in lower temperatures within the load, and the ice is put to better use by cooling the commodity.

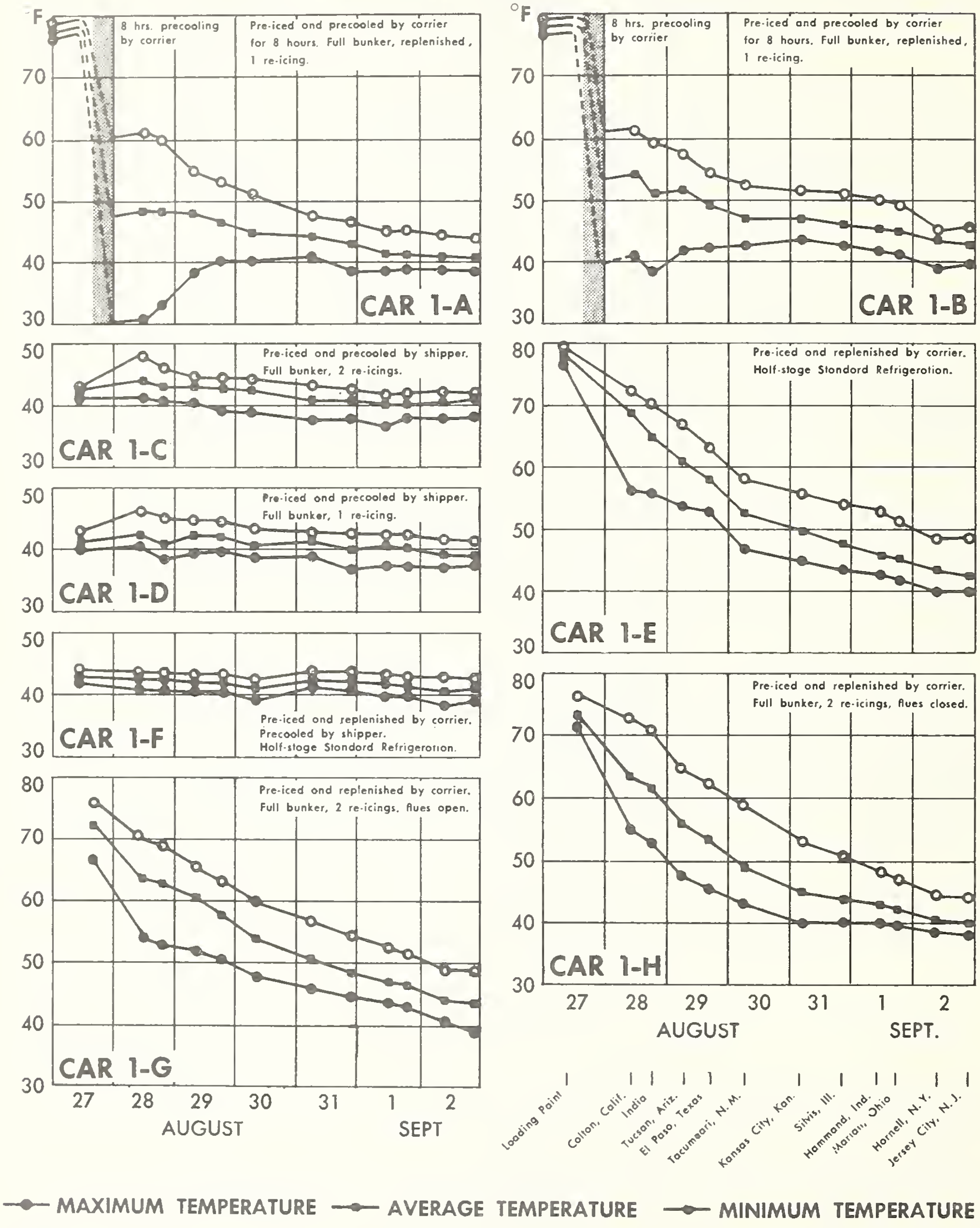
Results with Lemons

One pair of lemon cars was loaded at each of three houses. In each pair, one was loaded with ventilated cartons, the other with nonvented cartons. All of the cars were pre-iced and replenished. The pair of cars 1-K and 1-L received half-stage Standard Refrigeration. The other two pairs, 1-I and 1-J, and 1-M and 1-N, received full-bunker icing and were re-iced at El Paso and Blue Island (table 4). In each pair, loads in the ventilated cartons arrived at destination with a lower average fruit temperature than those in nonvented cartons. Car 1-I, with vented cartons, arrived with an average fruit temperature of 41.8° F., 10 degrees lower than its companion car with nonvented cartons. Differences in arrival temperatures of the other two pairs were not as great, being 6 degrees for 1-K and 1-L, the half-stage Standard Refrigeration cars, and 4 degrees for 1-M and 1-N, which received two re-icings en route (fig. 3 and table 5).

Southern California to New York, N.Y., 1959

Figure 2

VALENCIA ORANGE TEMPERATURES IN REFRIGERATOR CARS



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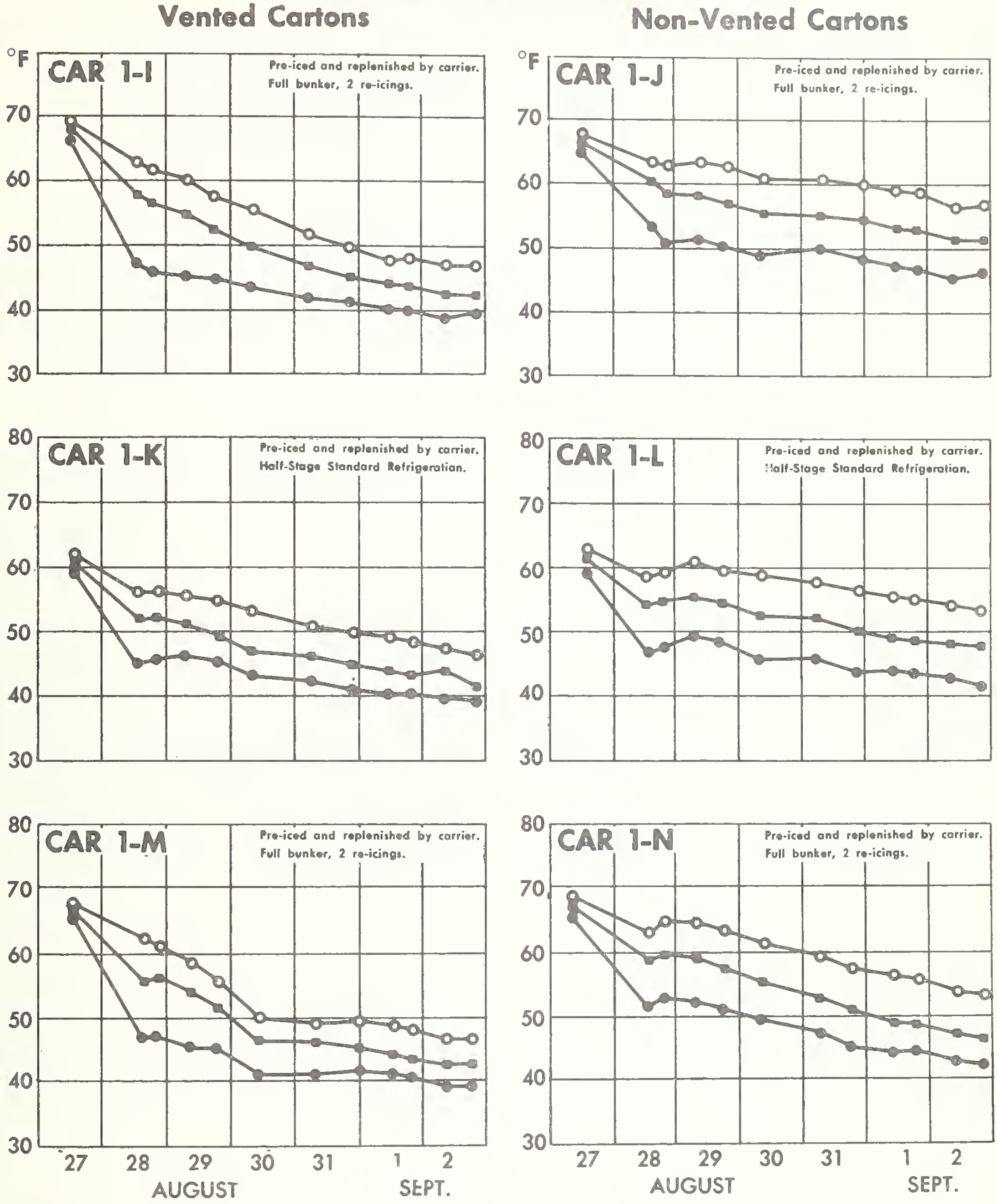
Southern California to New York, N.Y., 1959

Figure 3

LEMON TEMPERATURES IN REFRIGERATOR CARS



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Inspection of the lemons on the auction floor, the morning after arrival, revealed no noticeable difference among any of the lots. All lots were as fresh and firm in appearance as when packed, and no decay was noted.

Discussion: Lemons

It is evident from the fruit temperatures obtained that more refrigeration was used than was actually necessary for lemons. Previous recommendations (6) that two reicings in transit are not necessary on direct billings seem to be still valid with carton loads. This would also be true of half-stage Standard Refrigeration for lemons. One reicing at Kansas City would have sufficed on this test. This is true especially with the moderate temperatures encountered after El Paso and with cars unloading upon arrival in New York.

Until cars are more generally available in which temperatures can be controlled by a thermostat, transit temperatures will often be below the 55°-58° F. recommended for storage. The experience of shippers is that, for cured fruit (lemons which have been stored from 1 to 3 months), the lower temperatures during the transit period offer better decay control and thus better quality on arrival and through distribution channels than temperatures in the 55° to 58° range.

Test No. 2, Winter, Washington Navel Oranges

Cars in test No. 2 were loaded January 20, 1960, and arrived at Jersey City January 27.

Route and Running Time

This test from central California to Jersey City moved over the northern route via Southern Pacific, Union Pacific, Chicago and Northwestern, Indiana Harbor Belt, and Erie railways.

The total elapsed time from departure at Fresno to arrival at Jersey City was 134.5 hours. Of this, about 40 hours (29.7 percent) was standing time and 94.5 hours (70.3 percent) running time (table 6). The average train speed was 35 miles per hour over the 3,300-mile route. The trip over the same route in 1951 required 175 hours, of which 66 hours (37.7 percent) was standing time and 109 hours (62.3 percent) running time. The average speed then was 30.3 miles per hour.

Weather

A maximum outside air temperature of 69° F. was recorded on January 20, the day of loading. Outside temperatures on January 20-21 averaged 48.8°. When the train approached the summit of Donner Pass, outside temperatures dropped rapidly to below freezing, and averaged 22.4° for the remaining 100 hours of the trip to Jersey City. The average outside temperature for the entire trip was 28.4° (fig. 1).

Loads

Ten of the 12 cars (2-A through 2-F and 2-I through 2-L) were loaded with the bonded chimney pattern. Cars 2-G and 2-H had the spaced bonded-block load as described later in this report. The 18-hole carton was used in all 12 test loads.

Protective Services

Eight of the 12 test cars (2-A through 2-H) received full-bunker icing under rule 239, "pre-ice, replenish, do not re-ice". They were pre-iced at Bakersfield and Fresno on the morning of January 19, the day before loading, and replenished at Fresno between 4 a.m. and 7 a.m. on the day after loading (table 7).

The four remaining cars (2-I through 2-L) were billed "vents open to Ogden and Standard Ventilation beyond." Since the weather was not particularly severe before the cars reached Ogden, the test party did not change the vents on any of these cars. They would have been closed before Ogden had any fruit approached temperatures that were too low.

Equipment and Methods

As mentioned previously, the 12 cars in this test were all from the same series: all had electric fans and wall flues, and all had metal floor racks except car 2-A, which had wooden floor racks.

The wall flues of eight of the cars were closed at the top opening. These were 2-A, 2-B, 2-D, 2-E, 2-G, and 2-H, of the full-bunker pre-iced cars, and 2-I and 2-K of the cars billed "vents open to Ogden."

Equipment for obtaining temperatures was the same as in test No. 1, explained previously. The one difference was that the thermocouple cables and thermographs in test No. 2 were all placed in the forward ends of the cars. This was done to obtain more nearly uniform thermocouple temperatures between cars, especially those billed "vents open to Ogden."

Cars 2-A and 2-B were special two-bunker thermostatically controlled fan cars equipped with diesel-electric units to furnish continuous power to the fans irrespective of train speeds. The units were started as soon as loading was completed, and the fans operated under thermostatic control to destination. These fans operated at a speed equivalent to those in a regular fan car moving at about 60 miles per hour. This is almost double the average speed attained by a conventional fan on the trip, and it resulted in more rapid removal of heat from warm loads, especially during the first part of the trip when fans powered from the car wheels were normally at rest a large percentage of the time.

Car 2-A operated on the principle of reducing the fan speed to just balance convection currents after the commodity reached the thermostat setting. This was to prevent undesirable cooling at the bottom of the load by cold air flowing out from the bottom of the ice bunker.

The thermostat of car 2-A did not operate properly, as the thermostat bulb was installed in the wall flue at the floor rack level and the upper flue opening was blocked. Therefore, the bulb was surrounded by the cold air from the bunker on the car floor, which was at a temperature below the thermostat setting before the unit was started after loading. The fans consequently remained at slow speed from completion of loading to Sparks, Nev. Here the trouble was discovered and the fans then were operated at high speed by manual control for a total of 26 hours. The first period of high-speed fan operation was for 18 hours between Sparks and Ogden. The second period of 8 hours was between Rawlins and Sidney. This trouble has been eliminated by the manufacturer by redesigning the control system.

In car 2-B, four of the six fans were controlled by a thermostat set at 42° F. In this car, two fans at each end circulated air from the ice bunker to the load while refrigeration was needed. When the air temperature reached the thermostat setting, these fans stopped and dampers closed the openings to the bunker to stop convection. One fan at each end of the car operated continuously to circulate air within the commodity space only, bypassing the bunker. The thermostat bulb was placed in this air stream in the bypass duct to sense load temperature.

Results with Washington Navel Oranges

Thermostatically controlled fans, chimney loads.--As the fans in car 2-A did not operate at high speed until late in the trip and then for only a relatively short time, the cooling in this car was not normal nor uniform, as indicated by the average spread of 12 degrees between MQ and TA thermograph temperatures (table 8). Average fruit temperature at loading was 60° F. At Roseville, it was still 56°, and at Sparks 40 hours after loading, 54°. Then, with fans running at the correct speed for 18 hours, the average fruit temperature was reduced 9 degrees to 45°. In a car of this type with normal fan operation, a curve similar to that of car 2-B could be expected. The temperature curve for car 2-A is useful here in that the total time of high-speed operation (26 hours) is known for the trip, and a comparison of this curve with others of this test may be made (fig. 4).

Performance of car 2-B was excellent. The average fruit temperature at Roseville for nine thermocouples was 41.3° F. This was only 31 hours after loading and 10 hours after departure from Fresno. The drop in average fruit temperature was 14.3 degrees. The thermostatic control maintained fruit temperature above 40° for the remainder of the trip, as contrasted with a continued cooling below this point in some of the conventional fan cars. The average spread between maximum and minimum fruit temperatures was 6 degrees from Sparks to Jersey City. The difference between average MQ and TA thermograph temperatures was 3 degrees from Sparks to destination.

Standard refrigerator cars, chimney loads.--Cars 2-C, flues open, and 2-D, flues closed (pre-iced cars), were loaded at two different houses; average loading temperatures were 58.6° and 52.2° F., respectively. Average fruit temperatures for the trip were nearly the same for both cars. Car 2-D, with flues closed, had more nearly uniform temperatures, with only a 5-degree spread between average maximum and minimum fruit temperatures from Sparks to destination. This car reached an average fruit temperature of 45°, 50 hours after loading. Car 2-C, on the other hand, with flues open, showed a 10-degree spread between maximum and minimum for the same part of the trip, and required 56 hours to reach an average 45° fruit temperature, even though it received 8 hours of unscheduled car precooling at the packing house (table 8 and fig. 4).

Cars 2-E (flues closed) and 2-F (flues open) (pre-iced cars) were intended to duplicate the two just described. These were loaded from one packing house; the average temperature was 55° F. in both cars. In all comparisons, these cars fell below 2-C and 2-D in performance. Car 2-E, with flues closed, showed a slightly better rate of heat transfer with less spread (7 degrees) between average maximum and minimum than car 2-F, which had a 12-degree spread. It should be pointed out that the performance of car 2-E was curtailed by a possible temporary fan failure for about 20 hours, between Roseville and Ogden, indicated by a high TA thermograph temperature which averaged 10 degrees above the BA. The thermograph temperatures in MQ cartons and TA of cars 2-E and 2-F show an average difference of 10 and 12 degrees, respectively. This is equal to temperature differences found in car 2-A with below-normal fan operation. The time required for these cars to cool to an average fruit temperature of 45° was 90 hours for car 2-E and 70 hours for car 2-F.

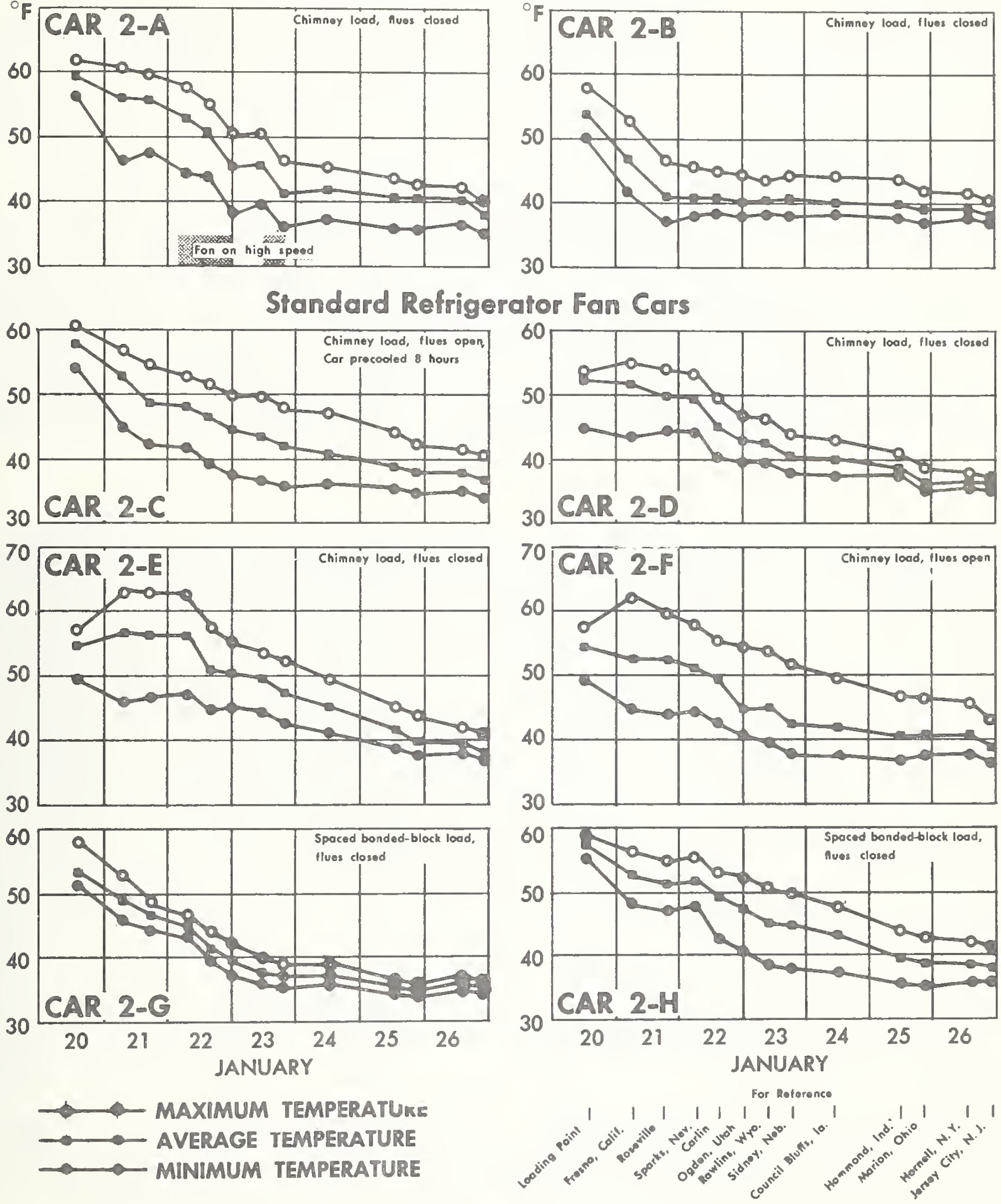
Standard refrigerator cars, spaced bonded-block load.--The last two cars of the test billed under rule 239 DNR ("Do not re-ice") were 2-G and 2-H. These were the only cars in the test that were not loaded with the bonded chimney load. The load was a spaced bonded block similar to the load used for Florida citrus shipments (7), except that eight lengthwise cartons were used in each layer of each bonded stack instead of seven. The total number of cartons was 1,062 per car, using a full 6-layer load.

Southern California to New York, N.Y., 1960 *Figure 4*

NAVEL ORANGE TEMPERATURES IN REFRIGERATOR CARS

Billed: Pre-ice — Replenish — Do Not Re-ice

Thermostatically-Controlled Fan Cars



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In this load, a two-tiered stack is built, each layer having five cartons crosswise of the car and eight cartons lengthwise (fig. 5). Crosswise and lengthwise cartons are alternated with each successive layer. With the end cartons placed against the car walls and all evenly spaced, 1-inch spaces were left between the sides of the lengthwise cartons; 2 1/2- to 3-inch spaces were left between the ends of the crosswise cartons. This pattern allows the air to pass vertically between the cartons through irregular but connected channels, with large surfaces of each carton exposed to the airstream.

Cars 2-G and 2-H had flues closed and were loaded at different packing houses. Average loading temperatures were 53.7° and 57.2° F., respectively. The fruit in car 2-G cooled to an average of 45° in 40 hours, with an average spread between maximum and minimum of 3 degrees between Sparks and Jersey City. The thermograph temperatures also showed an average spread of only 3 degrees between MQ and TA. These temperatures were approached only by the chimney load in car 2-B. The warmer fruit in the companion car, 2-H, required 72 hours to reach an average fruit temperature of 45°. The spread between average maximum and minimum from Sparks to Jersey City was 9 degrees because of an apparently irregular fan operation.

Comparison of spaced bonded-block and chimney loads.--The chimney load has from 36 to 40 vertical chimneys, depending upon the loading pattern in the doorway. Each chimney is about 5 1/2 inches square. These are the low-resistance points through which air flows with relative ease if not restricted by the floor racks. Each carton in the load has about 60 square inches of surface (1/10 of total area of sides and ends) exposed to a chimney.

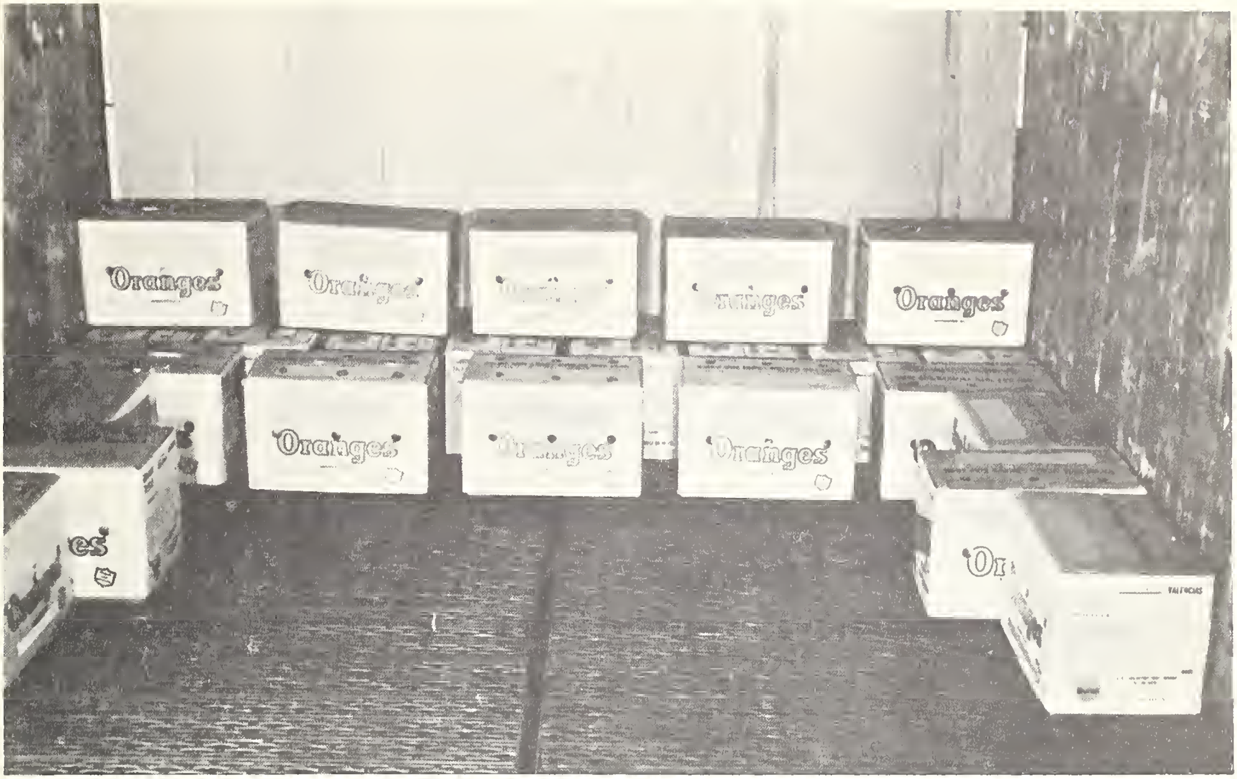
In the spaced bonded-block load, each of the lengthwise cartons, which make up 60 percent of the load, has an exposed area of 360 square inches. Since all of this is exposed to vertical channels, the lengthwise cartons have six times as much area exposed as do cartons in a chimney load. The area of the crosswise cartons exposed to the airstream varies with the load, but would in most cases be about the same as that of cartons in the chimney load. The exceptional performance of car 2-G can be attributed to the large surface of each carton exposed to an adequate airstream. The following data, taken from table 8, compare car 2-D, a chimney load, with car 2-G, the spaced bonded-block load:

Item	2-D	2-G
Average loading temperature	52.2° F.	53.7° F.
Cooled to 45° F. in--	50 hours	40 hours
Arrival temperature	36.7° F.	35.2° F.
Average fruit temperature	43.7° F.	40.9° F.
Average difference between max. & min.	5.0° F.	3.0° F.
Average difference between TA & MQ	7.0° F.	3.0° F.

Both of these cars had flues closed, and were pre-iced and replenished only. They were equipped with electric fans and metal floor racks.

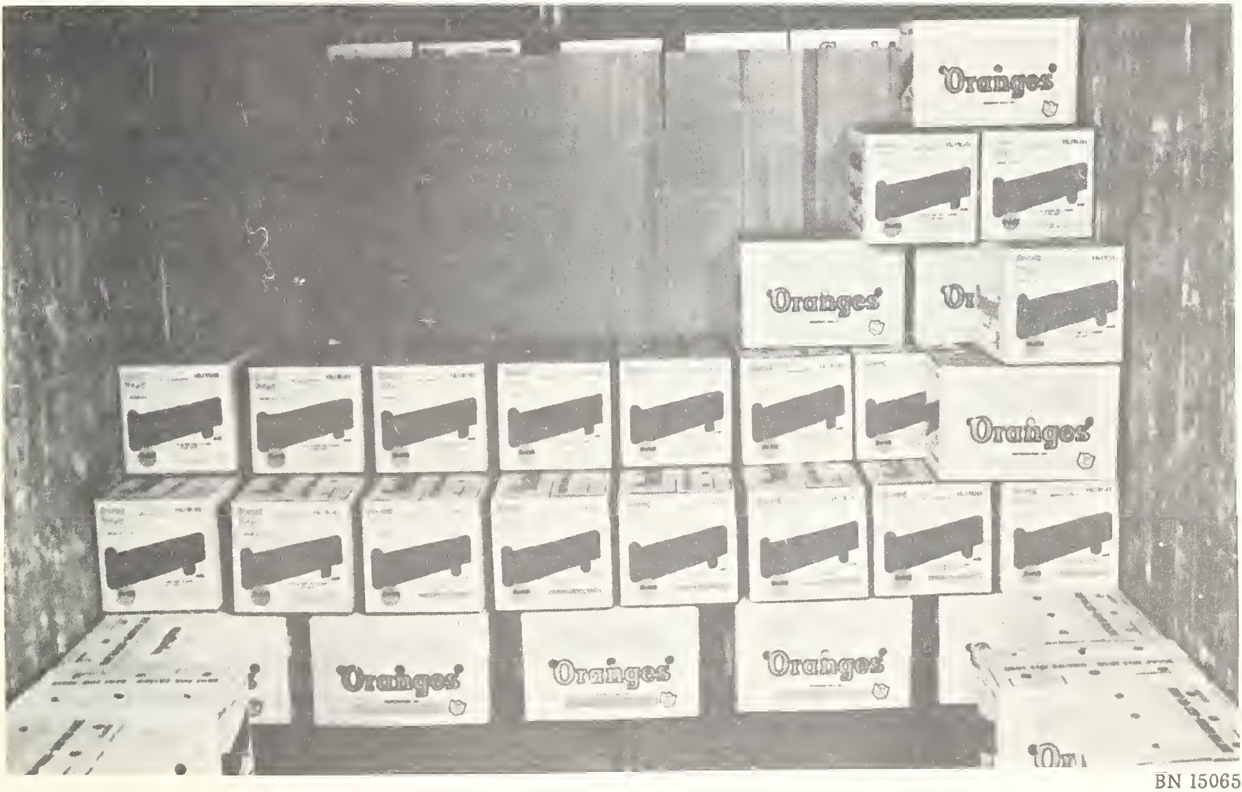
The performance of car 2-G was equalled only by that of car 2-B (thermostatically controlled fans), with a chimney load, which cooled to 45 degrees in about 24 hours. Car 2-B had an average spread between maximum and minimum temperatures of 6 degrees, compared with 3 degrees in car 2-G.

Ventilation service.--The four remaining cars of test 2 were billed "vents open to Ogden and Standard Vent beyond." Because outside air temperatures encountered east of Ogden were below 32°, the vents were kept closed from this point to destination. Cars 2-I (flues closed) and 2-J (flues open) had average loading temperatures of 56.6° and 51.5° F., respectively. Both cars cooled to 45° in about 70 hours after loading and had an average spread between maximum and minimum of 6 degrees. Average temperatures for the trip were 49.2° in car 2-I and 46.2° in car 2-J (table 8).



BN 15064X

Figure 5A



BN 15065X

Figure 5B

Cars 2-K (flues closed) and 2-L (flues open) had average loading temperatures of 61.7° and 53.8° F., respectively. Car 2-K did not reach 45° average fruit temperature before arrival in Jersey City, but averaged 50° at Ogden and 46° at Marion, Ohio, 70 hours later. Car 2-L, loaded almost 8° lower than the companion car, had an average fruit temperature of 48° at Ogden and 45° at Marion, which was about 130 hours after loading. These cars had an average spread between maximum and minimum of 9 degrees.

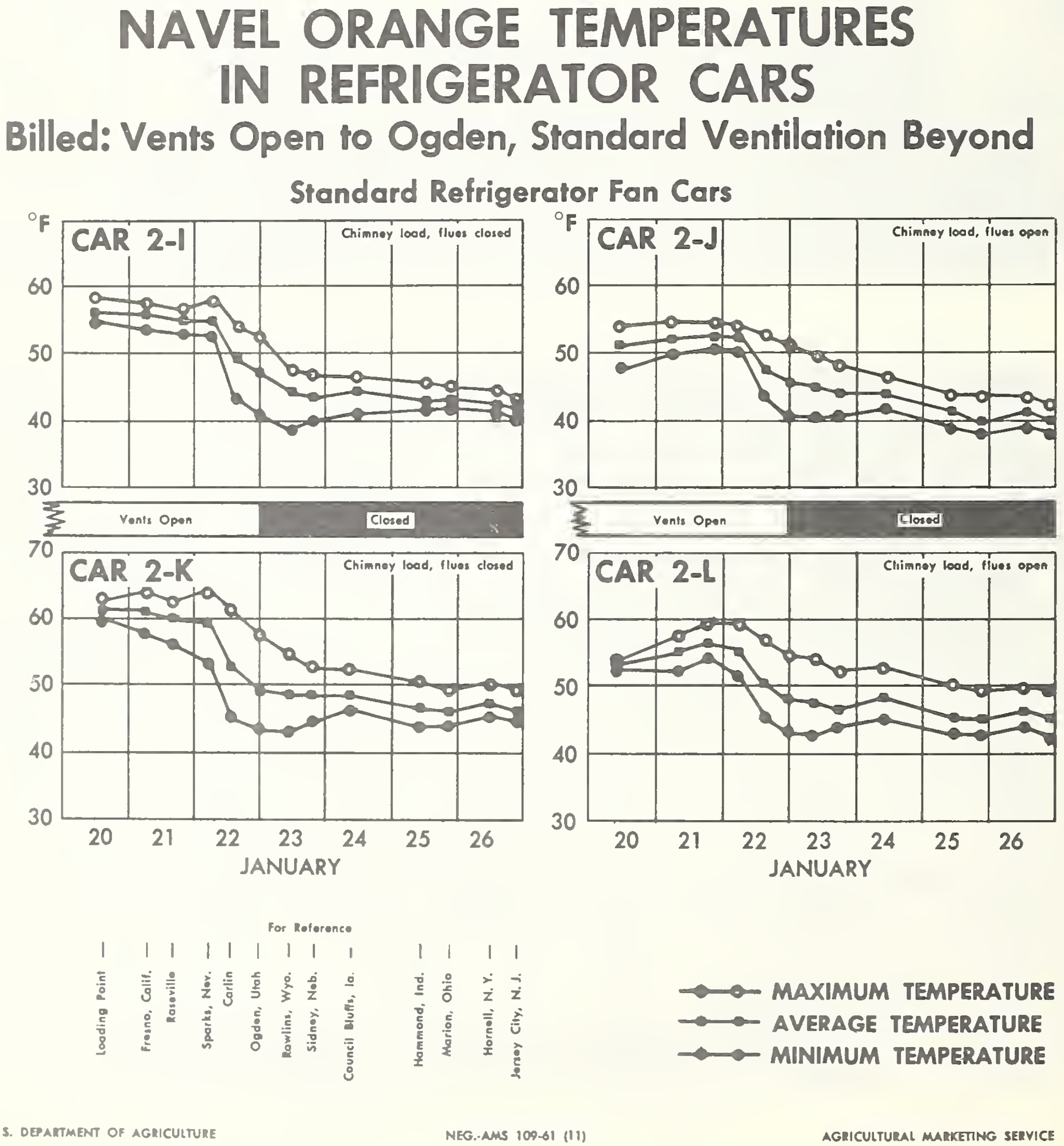
Average temperature reduction in these four cars between Sparks and Ogden, where the vents were closed, was as follows:

Flues closed - 2-I - 8.2 degrees   2-K - 9.7 degrees
Flues open - 2-J - 6.5 degrees   2-L - 7.7 degrees

These temperatures show effective cooling when the cars moved at high speed and outside temperatures were low (fig. 6).

Central Caifornia to New York, N.Y., 1960

Figure 6



Discussion: Washington Navel Oranges

These results clearly show how fan operation affects the initial cooling of fruit shipped from the central California area in iced cars. Under normal train operation, car speeds are relatively slow, with considerable standing time, for the first 24 to 36 hours while the cars are moved from loading points to where the train is finally made up. When the fans are operated continuously at maximum speed after loading, as in a diesel-powered thermostatically controlled fan car, cooling is rapid and uniform. In cars where fan speed is dependent on car motion, cooling is slow until the cars reach Donner Pass, after which train speeds are consistently higher.

In ventilated cars, not only is train speed an important factor but low outside air temperatures also are required. These low temperatures are not usually encountered until near Donner Pass; hence, cooling is delayed until this necessary combination of sustained high speed and cold weather are experienced. This is an important point to be considered in selecting the proper protective service for nonprecooled oranges at this time of year.

However, after the cold weather was reached, some 40 hours after loading, cooling in some of the ventilated cars was as rapid as in some of the pre-iced conventional fan cars. There is evidence that in one ventilated car (2-K), fan operation was not normal because of the wide spread between top air (TA) and midquarter (MQ) fruit temperatures during the period when the vents were open in cold weather. After the vents were closed, fruit temperatures remained fairly constant in the un-iced cars for the rest of the trip, despite the relatively low outside temperatures encountered. This is in contrast to the continued cooling generally found in the iced cars.

Closing the flues resulted in slightly more cooling and somewhat more uniform transit temperatures than when they were left open, in both iced and ventilated cars.

In the spaced bonded-block load, more surface area of the cartons is exposed to the cooling air than in the conventional chimney load. This results in faster cooling and more uniform transit temperatures, which are advantages with carton-packed, nonprecooled fruit.

The arrival condition of the fruit shipped in the 12 cars in this test and the trade reaction to its quality may be described by the following statement from the commercial receiver's report:

"Temperatures taken at doorway upon arrival were very satisfactory on all cars, with little variation of temperatures from top to bottom. Although ventilated cars arrived with slightly higher temperatures, there was practically no difference in condition or appearance of fruit in any car; so much so that a number of the trade expressed the opinion that it was the best display of fruit seen for a long time."

TABLE 1.--Trip log, test 1, Oxnard, Calif., to New York market, August - September 1959

Date	Station	Arrive	Depart	Standing time		Outside temperature
		P.s.t.	P.s.t.	Hr.	Min.	°F.
August 28	Colton, Calif.		1:10 p.m.	0	0	87
	Beaumont	2:30 p.m.	3:00 p.m.	0	30	94
	Palm Springs	2:45 p.m.	4:30 p.m.	0	45	96
	Indio	5:45 p.m.	9:25 p.m.	3	40	97
	En route	11:00 p.m.	11:15 p.m.	0	15	94
August 29		M.s.t.	M.s.t.			
	Yuma, Ariz.	1:26 a.m.	2:03 a.m.	0	37	90
	Tucson	7:55 a.m.	8:30 a.m.	0	37	78
	En route	8:35 a.m.	8:45 a.m.	0	10	80
	El Paso, Tex.	5:30 p.m.	10:00 p.m.	4	40	97
	En route	11:00 p.m.	11:15 p.m.	0	15	90
August 30	Tucumcari, N. Mex.	7:45 a.m.	11:30 a.m.	3	45	68
		C.s.t.	C.s.t.			
	Dalhart, Tex.	1:55 p.m.	2:15 p.m.	0	20	87
	Liberal, Kan.	5:10 p.m.	5:30 p.m.	0	20	96
August 31	Kansas City	5:00 a.m.	10:30 a.m.	5	30	69
	En route	12:00 noon	12:15 p.m.	0	15	73
	Trenton	2:20 p.m.	2:35 p.m.	0	15	74
	Rock Island, Ill.	9:45 p.m.	9:55 p.m.	0	10	74
	Silvis	10:30 p.m.	1:00 a.m.	2	30	73
September 1	Blue Island	4:15 a.m.	10:00 a.m.	5	45	70
	Hammond, Ind.	10:20 a.m.	1:20 p.m.	3	0	76
	Huntington	4:00 p.m.	4:10 p.m.	0	10	74
	Marion, Ohio	7:00 p.m.	10:00 p.m.	3	0	71
		E.s.t.	E.s.t.			
September 2	Kent	2:00 a.m.	2:05 a.m.	0	5	73
	Salamanca, N. Y.	7:45 a.m.	7:50 a.m.	0	5	78
	Hornell	9:00 a.m.	12:30 p.m.	3	30	84
	Susquehanna, Pa.	3:25 p.m.	3:50 p.m.	0	15	84
	Port Jervis, N. Y.	6:30 p.m.	6:35 p.m.	0	5	76
	Croxton, N. J. (New York market area)	9:30 p.m.	---	0	0	77

Total standing time.......... 41 1/2 hours
Total running time........... 87 hours
Total elapsed time...........128 1/2 hours

TABLE 2.--Protective services used for 8 test cars of Valencia oranges and 6 cars of lemons shipped from southern California to New York market in test 1, August - September 1959

Commodity and car designation	Half-stage standard refrigeration	Full-bunker icing	Pre-cooled 8 hours by carrier	Pre-cooled by shipper	Pre-iced by carrier	Pre-iced by shipper	Replenished	Re-iced once	Re-iced twice
Oranges									
1-A		X	X		X		X	X	
1-B		X	X		X		X	X	
1-C		X		X		X			X
1-D		X		X		X		X	
1-E	X				X		X		
1-F	X			X	X		X		
1-G		X			X		X		X
1-H		X			X		X		X
Lemons									
1-I		X			X		X		X
1-J		X			X		X		X
1-K	X				X		X		
1-L	X				X		X		
1-M		X			X		X		X
1-N		X			X		X		X

TABLE 3.--Ice supplied to 8 test cars of Valencia oranges, test 1, shipped from southern California to New York market, August - September 1959

Date	Station	Time	Amount of ice supplied to designated cars							
			1-A	1-B	1-C	1-D	1-E	1-F	1-G	1-H
		P.s.t.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Aug. 25	Oxnard[1]...........	11:00 a.m.	11,500	11,500	---	---	---	---	---	---
26	Oxnard[1]...........	11:00 a.m.	---	---	---	---	6,000	6,000	11,500	11,500
27	Orange[2]...........	8:00 a.m.	---	---	11,500	11,500	---	---	---	---
	Oxnard[3]...........	10:00 p.m.	---	---	---	---	3,000	3,300	3,700	4,500
	Los Angeles[3]......	9:00 p.m.	6,600	6,300	---	---	---	---	---	---
		M.s.t.								
29	Yuma, Ariz........	1:30 p.m.	---	---	---	---	4,800	2,000	---	---
	El Paso, Tex......	5:30 p.m.	---	---	1,900	---	3,100	2,600	8,500	8,500
		C.s.t.								
31	Kansas City, Mo...	7:00 a.m.	7,500	6,300	---	6,000	4,800	4,200	---	---
Sept. 1	Blue Island, Ill..	8:00 a.m.	---	---	---	---	1,800	2,200	9,500	9,500
	Marion, Ohio......	7:15 p.m.	---	---	5,100	---	800	900	---	---
		E.s.t.								
2	Hornell, N. Y.....	10:00 a.m.	---	---	---	---	2,000	2,000	---	---
Total ice supplied, to Jersey City			25,600	24,100	18,500	17,500	26,300	23,200	33,200	34,000
Ice remaining, at Jersey City...............			3,840	5,760	5,650	3,840	1,500	4,500	8,620	7,680
Total ice melted in transit.................			21,760	18,340	12,850	13,660	24,800	18,700	24,580	26,320

---

[1] Pre-iced by carrier.
[2] Pre-iced by shipper.
[3] Replenished.

TABLE 4.--Ice supplied to 6 test cars of lemons, test 1, shipped from southern California to New York market, August - September 1959

Date	Station	Time	Amount of ice supplied to designated cars					
			1-I	1-J	1-K	1-L	1-M	1-N
		P.s.t.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Aug. 26	Oxnard[1]	11:00 a.m.	11,500	11,500	6,000	6,000	11,500	11,500
27	Oxnard[2]	10:00 p.m.	3,700	4,000	3,600	3,300	4,800	4,500
		M.s.t.						
29	Yuma, Ariz.	1:30 p.m.	---	---	2,100	1,600	---	---
	El Paso, Tex.	5:30 p.m.	5,100	4,800	1,800	2,200	5,000	4,300
		C.s.t.						
31	Kansas City, Mo.	7:00 a.m.	---	---	4,800	3,800	---	---
Sept. 1	Blue Island, Ill.	8:00 a.m.	9,500	6,800	2,200	2,400	8,500	7,600
	Marion, Ohio	7:15 p.m.	---	---	1,000	800	---	---
		E.s.t.						
2	Hornell, N. Y.	10:00 a.m.	---	---	2,400	2,000	---	---
Total ice supplied, to Jersey City			29,800	27,100	23,900	22,100	29,800	27,900
Ice remaining, at Jersey City			5,760	5,760	4,500	4,500	10,060	8,620
Total ice melted in transit			24,040	21,340	19,400	17,600	19,740	19,280

---

[1] Pre-iced by carrier.
[2] Replenished.

TABLE 5.--Average fruit and air transit temperatures for 14 test cars of oranges and lemons shipped from southern California to New York market (test 1), August 28 - September 3, 1959

Commodity and car number	Average fruit temperature				Time after loading until average fruit temperature of--		Average temperature, Tucson to Jersey City						
	Thermocouple						Thermocouple			Thermograph			
							Fruit			Air			Carton
	Loading	Arrival	Reduction	Trip average			Max.	Min.	Dif.	BA	TA	MQ	Dif. MQ-TA
	°F.	°F.	°F.	°F.	45°	55°	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Oranges:													
1-A.........	77.4	40.2	37.2	44.4	[5] 96	---	47	40	7	---	44	46	2
1-B.........	77.7	43.1	34.6	47.9	[5] 154	---	51	42	9	---	44	53	9
1-C[1]........	44.2	40.1	4.1	41.9	0	---	44	39	5	---	43	44	1
1-D[1]........	43.6	39.7	3.9	39.9	0	---	43	39	4	43	42	44	2
1-E.........	78.1	43.5	34.6	54.9	128	---	55	45	10	45	45	55	10
1-F.........	42.8	41.1	1.7	41.9	0	---	43	40	3	44	43	43	0
1-G.........	72.3	44.0	28.3	54.6	134	---	56	46	10	44	45	55	10
1-H[2]........	74.3	40.4	33.9	51.4	84	---	53	42	11	45	45	50	5
Lemons:													
1-I[3]........	68.6	41.8	26.8	50.0	---	36	51	41	10	43	42	50	8
1-J[4]........	66.0	51.6	14.4	56.2	---	69	60	48	12	48	49	60	11
1-K[3]........	61.7	41.6	20.1	48.3	---	24	51	42	9	46	45	52	7
1-L[4]........	61.4	47.4	14.0	52.0	---	42	56	45	11	44	44	55	11
1-M[3]........	67.1	42.4	24.7	49.5	---	24	50	42	8	44	43	51	8
1-N[4]........	67.4	46.5	20.9	54.1	---	72	58	46	12	44	45	56	11

---

[1] Cars 1-C and 1-D received no replenishment and were loaded with cartons having slotted-type ventilation.

[2] Flues closed in 1-H; flues open in all other cars.

[3] Vented cartons.

[4] Nonvented cartons.

[5] Cars 1-A and 1-B loaded 1 day earlier to allow time for 8 hours of precooling by carrier.

TABLE 6.--Trip log, test 2, Fresno, Calif., to New York market, January 1960

Date	Station	Arrive	Depart	Standing time		Outside temperature
Jan.		P.s.t.	P.s.t.	Hr.	Min.	°F.
21	Fresno, Calif..........	---	9:35 a.m.	---	---	52
	Lengard................	10:45 a.m.	11:15 a.m.	0	30	52
	Roseville..............	2:45 p.m.	8:15 p.m.	5	30	50
	Rockland...............	9:10 p.m.	9:20 p.m.	0	10	48
22	Norden.................	2:30 a.m.	3:00 a.m.	0	30	32
	Sparks, Nev............	4:20 a.m.	6:05 a.m.	1	45	32
	Imlay..................	9:25 a.m.	9:40 a.m.	0	15	28
	Carlin.................	1:10 p.m.	2:10 p.m.	1	0	40
	Wells..................	4:00 p.m.	4:30 p.m.	0	30	34
	Ogden, Utah............	9:30 p.m.	12:15 a.m.	1	45	19
		M.s.t.	M.s.t.			
23	Green River, Wyo.......	5:45 a.m.	6:00 a.m.	0	15	20
	Rawlins................	9:15 a.m.	9:40 a.m.	0	25	28
	Laramie................	12:40 p.m.	1:05 p.m.	0	25	34
	Cheyenne...............	3:00 p.m.	3:15 p.m.	0	15	34
	Sidney, Nebr...........	5:20 p.m.	5:45 p.m.	0	25	32
	North Platt............	8:00 p.m.	10:00 p.m.	1	0	10
		C.s.t.	C.s.t.			
	Grand Island...........	1:30 a.m.	2:30 a.m.	1	0	5
24	Council Bluffs, Ia.....	6:10 a.m.	1:10 p.m.	7	0	0
	Clinton................	9:00 p.m.	9:20 p.m.	0	20	10
25	Proviso, Ill...........	12:30 a.m.	6:30 p.m.	5	0	15
	Hammond, Ind...........	9:30 a.m.	2:00 p.m.	4	30	25
	Huntington.............	6:00 p.m.	6:20 p.m.	0	20	28
	Marion, Ohio...........	8:20 p.m.	11:20 p.m.	3	0	36
		E.s.t.	E.s.t.			
26	Meadeville, Pa.........	7:00 a.m.	8:15 a.m.	1	15	32
	Salamanca, N. Y........	10:15 a.m.	10:25 a.m.	0	10	25
	Hornell................	12:30 p.m.	3:35 p.m.	2	45	28
	Croxton Yards, N. J.... (New York market area)	11:40 p.m.	---	---	---	26

Total standing time........	40 hours
Total running time.........	94.5 hours
Total elapsed time.........	134.5 hours

TABLE 7.--Ice supplied to 8 test cars of navel oranges, test 2, shipped from central California to New York market, January 1960

Date	Station	Time	Amount of ice supplied to designated cars							
			2-A	2-B	2-C	2-D	2-E	2-F	2-G	2-H
Jan.		P.s.t.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
19	Bakersfield[1]......	10:00 a.m.	---	---	---	---	---	---	11,500	11,500
	Fresno[1]...........	10:00 a.m.	11,500	11,500	11,500	11,500	11,500	11,500		
21	Fresno[2]...........	4:30 a.m.	600	700	1,200	---	---	---	---	---
	Fresno[2]...........	6:30 a.m.	---	---	---	---	---	---	500	700
	Fresno[2]...........	7:00 a.m.	---	---	---	700	800	800	---	---
	Total ice supplied, to Jersey City.....		12,100	12,200	12,700	12,200	12,300	12,300	12,000	12,200
	Ice remaining, at Jersey City..........		6,360	7,070	5,890	5,650	5,890	6,590	6,130	6,360
	Total ice melted in transit............		5,740	5,130	6,810	6,550	6,410	5,710	5,870	5,840

[1] Pre-iced by carrier.
[2] Replenished.

TABLE 8.--Average fruit and air transit temperatures for 12 test cars of navel oranges, test 2, shipped from central California to New York market, January 20-27, 1960

Car designation and service	Average fruit temperature				Hours after loading to reach 45° fruit average	Average temperature, Sparks to Jersey City						
	Thermocouple					Thermocouple			Thermograph			
	Loading	Arrival	Reduction	Trip average		Fruit			Air			Carton
						Max.	Min.	Dif.	BA	TA	MQ	Dif. MQ-TA
Pre-ice and replenish	°F.	°F.	°F.	°F.		°F.	°F.	°F.	°F.	°F.	°F.	°F.
2-A..........	59.9	37.9	22.0	47.5	72	48	39	9	39	35	47	12
2-B..........	55.6	38.1	17.5	42.0	24	44	38	6	38	38	41	3
2-C..........	58.6	36.9	21.7	44.8	56	47	37	10	36	35	42	7
2-D..........	52.2	36.7	15.5	43.7	50	44	39	5	35	34	41	7
2-E..........	55.2	37.9	17.3	48.3	90	49	42	7	44	39	49	10
2-F..........	55.0	38.3	16.7	46.1	70	51	39	12	36	35	47	12
2-G..........	53.7	35.2	18.5	40.9	40	40	37	3	35	33	36	3
2-H..........	57.2	38.2	19.0	46.6	72	48	39	9	38	33	40	7
Vents open												
2-I..........	56.6	41.6	15.0	49.2	70	49	43	6	38	36	44	8
2-J..........	51.5	39.3	12.2	46.2	70	48	42	6	39	36	44	8
2-K..........	61.7	46.3	15.4	52.2	Over [1] 160	54	45	9	42	40	55	15
2-L..........	53.8	45.2	8.6	49.7	130	53	44	9	42	41	49	8

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[1] Did not reach 45° before arrival, 160 hours after loading.

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